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A COMPARATIVE STUDY OF EARLY HISTORIC "TEWA" POTTERY

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INTRODUCTION

Pottery has long been used by archaeologists to trace trade routes and to determine the geographic extent of a given culture. Various archaeometric methods have supplemented the traditional stylistic analyses, particularly when only small, unidentifiable sherds of culinary ware are available (Bower and others, 1974; Hall and others, 1973; Isphording, 1974; Snow and Fullbright, 1976). The parametric data generated by an elemental-analysis method such as neutron activation, atomic absorption, or x-ray fluorescence are particularly useful when combined with computer-generated pattern recognition (Ward, 1974).

In this study pueblo pottery of the late protohistoric or early historic period was analyzed by x-ray methods in order to provide information about the number and locations of the historic pueblos trading with the early Spanish settlers in the Santa Fe area. After 1000 A.D., the Espanola Basin was primarily the home of the Tewa-speaking pueblos (Fig. 1), though a linguistically similar group known as the Tano (or southern Tewa) lived south of Santa Fe in the Galisteo River basin. This southern group may have been split off from the northern Tewa when the Keresans settled the area around the confluence of the Jemez and Rio Grande Rivers between 1200 and 1300 A.D. The Towas, who settled along the Jemez River about 1250 A.D., may also have been split at some point, as some authors feel that Pecos was also Towa, while others hold that it was probably Tewa (Ford and others, 1972). The Tiwas, who are generally believed to have developed in the Rio Grande valley originally, were displaced by the later pueblos to the Taos and Albuquerque areas.

Primarily Tewa Red culinary ware (which might be gray or black if it is fired in a reducing atmosphere) and Tewa Polychrome ware (Fig. 2) were used for the analysis. The Tewa Polychrome and Red wares were introduced at about the same time as the first Spanish settlement, and their popularity may have been influenced by the Spanish or the Mexican Indians who came with them. The Tewa Polychrome jars and bowls are distinctive because of their design band, which is white with thin, black line decorations made with carbon-based pigment instead of the mineral-based pigment generally used on pottery elsewhere. A red slip was usually applied both above and below this belly band (Fig. 2), though in the late 18th or early 19th century the red was used only in a band below the design (Harlow, 1967), and the original Tewa Red and Polychrome wares faded from production. Some Biscuit wares which were made by the northern Tewa, and some Glaze wares made by the southern Tewa or the Keresans, were also analyzed. These latter wares date from 1400 to 1600 A.D. (Dittert and Plog, 1980).

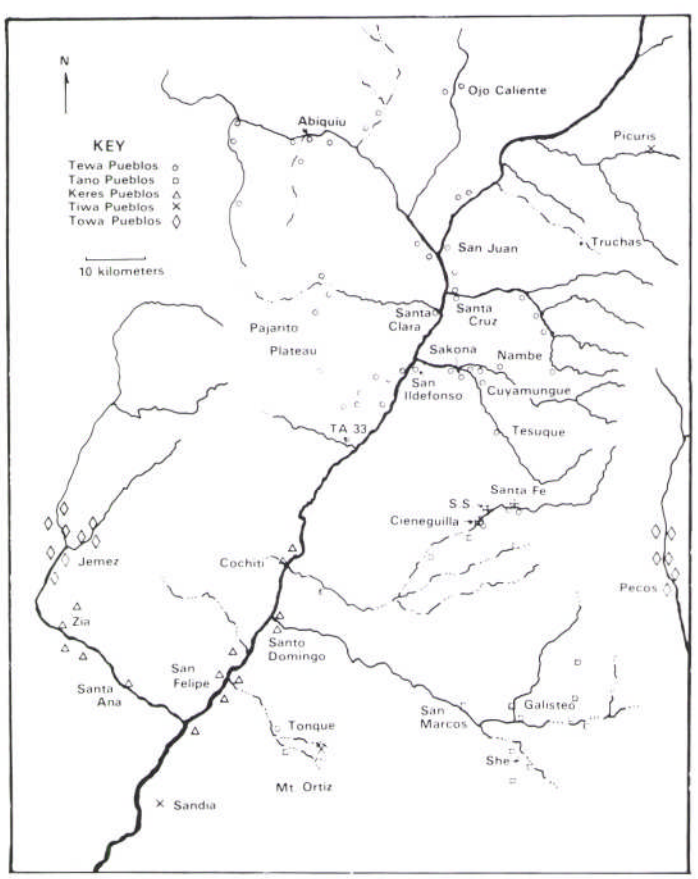

FIGURE 1. Location of protohistoric (ca 1400–1540 A.D.) and early historic (ca 1540–1750 A.D.) pueblos and Spanish settlements of the upper Rio Grande valley (Swanton, 1952).

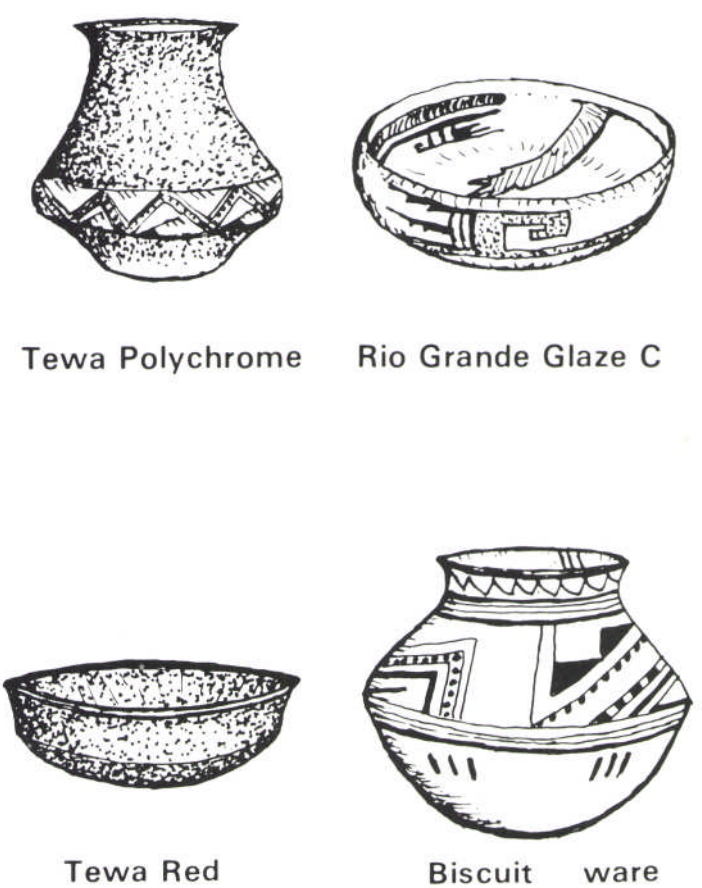

FIGURE 2. Typical pottery of the upper Rio Grande valley, 1450–1730 A.D. Stipling indicates red slip.

Besides providing useful information for understanding cultural interactions between the Spanish settlers and the native populations, a work such as this should provide archaeometrically useful data. Although the efficacy of XRF for archaeometric analyses is well known, the minimum number of samples and parameters to be measured on those samples is not known for the pottery of this area. This study will provide knowledge of what constitutes a diagnostic set of parameters as well as initiating a library of data for comparison with further analyses of pottery from this region. By extending these analyses into other historic, ceramic, geographic, and cultural groups, questions about the origins of the various pueblos and their interactions through time can eventually be addressed as well.

METHOD

Samples from 14 pueblos in the northern Rio Grande valley were collected by snipping off 1-2 g pieces from undecorated portions of the wares. For simplicity, the red slip or glaze was not removed from the analyzed pieces. This presented few problems in the analysis or the conclusions, and it actually increased separation between pottery groups. Generally, however, analyzing the surface separate from the body would be the best procedure. Most of the samples were taken from the collection of sherds at the Museum of New Mexico Laboratory. The 1-2 g weight was selected for these relatively homogenous samples as adequate to give analyses which would be within 5% precision with 95% confidence (Bromund and others, 1976) for each sherd. Of course, the variance between sherds at a given site might well be greater than this, especially if they came from different sources. Thirty samples of red ware from a Spanish settlement located along the Santa Fe River just west of the Santa Fe airport (site 16/T), and 12 samples from two other Spanish settlements (LA 16 and LA 930) located on either side of the main site were analyzed with the pueblo samples. An additional 23 prehistoric samples from three sites (Cochiti, Truchas, and TA 33) were analyzed so that more complete comparisons could be made.

A preliminary study of 20 sherds demonstrated that sample sizes of three to five sherds would be satisfactory for discerning differences between pueblos. The number of samples needed can be estimated from n = (Student's t statistic x the standard deviation / the difference in the means of two pueblos to be discerned)^2. For example, for separating Cuyamungue and Tesuque using only the strontium data, n = (3.2 x 53/(271-160)^2 = 3 samples of each pueblo. If other elements were also included, even fewer samples could be used, though the chance of getting an imported pot without recognizing it as such becomes too great to warrant the savings.

After grinding the samples in a mullite mortar and pestle, 1 g of the powder and 9 g of lithium tetraborate were fused at 1150°C for 20 minutes with constant vigorous agitation. Glass disks 3 cm in diameter were poured from the melt and these were analyzed for 10 major (Na, Mg, Al, Si, P, K, Ca, Ti, Mn, and Fe) and 12 trace (Ba, La, Ce, V, Cr, Ni, Co, Zn, Sr, Rb, Y, and Zr) elements using a Rigaku model 3064 x-ray fluorescence (XRF) instrument.

X-ray powder-diffraction (XRD) spectra were collected on selected sherds in order to identify the different minerals present in the samples from the Spanish settlement. A Siemens model D500 was used to scan in 0.02-degree increments from a two theta of 2 to 36 degrees, counting for two seconds at each increment. A binocular microscope was also used to visually sort the sherds based upon the appearance of their temper.

The cluster analysis was calculated using a program based on the distance coefficient presented in Davis (1973) after normalizing the data to z-scores. The major oxides (except CaO) and Sr were used as a diagnostic set for the statistical analyses. CaO was not used because of Ca contamination from the ground water in this area. If it were included, the composition would not accurately reflect the composition the pot had when it was made. The remaining trace elements were not used in the diagnostic set as they did not have greater variances between pueblos than they had within pueblos, implying they would not add significantly to the discerning ability of the diagnostic parameters while they would increase the complexity of the calculations. Since the calculations were done with a small computer, except for Sr, the tract elements were dropped for simplicity.

RESULTS AND DISCUSSION

The sample sizes, means, and standard deviations of 10 major oxide: and Sr for five historic pueblos are presented in Table 1. Tewa rec pottery collected from three Spanish settlements located along the Sant; Fe River, Biscuit ware from four northern Tewa pueblos, and prehistoric pottery from the surrounding region arc presented in Tables 2, 3, an 4, respectively. A typical sherd from the Espanola Basin would fal within the following ranges of composition: 1.0-2.0% Na_2O, 1.5-2.59 MgO, 14.0-16.0% Al_2O,, 62.0-65.5% SiO_2, 0.1-0.3% $1_{3_2}O_5$, 3.0-4.0% K_2O, 2.0-8.0% CaO, 0.4-0.8% TiO_2, 0.02-0.2% MnO, anc 3.5-5.5% Fe_2O_3. For the trace elements it would have 300-1000 ppn Ba, 20-80 ppm La, 50-180 ppm Ce, 10-60 ppm V, 10-40 ppm Cr 0-50 ppm Ni, 0-20 ppm Co, 70-130 ppm Zn, 100-400 ppm Sr, 100-170 ppm Rb, 20-80 ppm Y, and 150-400 ppm Zr. For La, Ce, Ni and Co these concentrations are at or below the detection limits.

From the data in Tables I , 3, and 4 it is apparent that the sherd! from the northern portion of the Espanola Basin contain higher leveh of SiO_2 and K_2O and lower levels of Al_2O, and Sr when compared tc the sherds from south of Santa Fe, making it possible to discern dif ferences between the pueblos and to approximately locate the source of the Spanish settlement pottery. This difference in the ratios of the elements suggests that more alkaline feldspars are present in the northerr samples and more calcic feldspars, which concentrate Sr, are favorer in the southern samples. The higher concentration of Ca in the SS samples compared to SS 1 supports this hypothesis, as any groundwater contamination should be fairly similar for these two groups 01 sherds.

For most of the pueblos there is enough of a distinction, so ar unknown sherd can be "fingerprinted" using pattern-recognition methods. No temporal trend is apparent. Rather, pottery made at a giver locale tends to have the same composition throughout history, though this has not been studied over a very large time span. The differences in the mean compositions of the Biscuit wares (Table 3) from Ojc Caliente, Pioge, Tesuque, and San lldefonso imply different centers of production for these pueblos. The differences in the Glaze wares from Tongue and She, and in the Tewa wares from Santa Clara, Sakona, Cuyamungue Tesuque, and Pecos also imply different centers. The compositions for Truchas, TA 33, and Cochiti, which contain pottery

TABLE 1. Major oxide (%) and trace-element (ppm) composition of Tewa Red and Polychrome wares from five pueblos.

Sample Size	Santa Clara (LA 925) 4	Sakona (LA 1065) 7	Cuyamungue (LA 38) 16	Tesuque (LA 1064) 8	Pecos (LA 625) 5
Na_2O	1.48 0.17	1.42 0.15	1.32 0.20	1.34 0.16	1.49 0.21
MgO	2.32 0.56	2.22 0.14	2.39 0.17	2.07 0.36	2.15 0.33
Al_2O_3	15.46 0.83	14.54 0.63	15.00 0.45	15.04 1.71	15.15 0.88
SiO_2	63.96 3.14	64.08 1.82	62.56 1.94	64.86 0.92	64.28 1.83
P_2O_5	0.15 0.03	0.15 0.05	0.17 0.06	0.13 0.04	0.23 0.08
K_2O	3.91 0.35	3.93 0.10	3.95 0.20	3.48 0.22	3.73 0.64
CaO	4.39 0.95	4.41 0.57	5.05 0.90	4.47 1.81	4.27 1.64
TiO_2	0.62 0.10	0.60 0.06	0.61 0.06	0.56 0.06	0.55 0.08
MnO	0.15 0.08	0.10 0.01	0.13 0.03	0.09 0.02	0.08 0.02
Fe_2O_3	4.38 0.93	4.69 0.35	4.69 0.25	4.45 0.74	4.80 0.70
Sr	280 71	318 40	271 50	161 56	192 72

TABLE 2. Major oxide (%) and trace-element (ppm) composition of pottery from selected early historic Spanish settlements.

	SS 1 (16/T)[1]	SS 2 (16/T)[1]	Santa Fe[2] (LA 930)	Cieneguilla[3] (LA 16)
Sample Size	10	20	7	5
Na_2O	1.40 0.40	1.66 0.26	1.41 0.22	1.46 0.18
MgO	1.85 0.27	2.28 0.18	1.75 0.22	2.03 0.33
Al_2O_3	14.09 2.01	17.12 0.76	14.46 0.86	14.44 0.93
SiO_2	65.48 2.08	61.08 1.07	66.65 2.47	65.61 1.90
P_2O_5	0.21 0.06	0.20 0.04	0.36 0.33	0.17 0.02
K_2O	3.21 0.61	2.82 0.12	3.60 0.28	3.84 0.36
CaO	4.77 1.69	5.46 0.63	4.45 1.59	4.30 1.06
TiO_2	0.55 0.11	0.83 0.11	0.54 0.03	0.47 0.03
MnO	0.08 0.03	0.13 0.03	0.10 0.02	0.08 0.01
Fe_2O_3	4.26 0.95	6.54 0.68	4.19 0.44	3.99 0.34
Sr	216 55	519 58	126 66	197 52

[1]All pottery appeared to be culinary red ware.
[2]Pottery consisted of a mixture of red wares.
[3]Sample was composed entirely of Tewa Polychrome plates, which were made exclusively for the Spanish.

TABLE 3. Major oxide (%) and trace-element (ppm) composition of protohistoric pottery of the northern Rio Grande valley.

	Bisquitware B Ojo Caliente	Bisquitware B Pioge (LA 144)	Bisquitware A San Ildefonso (LA 122)	Bisquitware B Tesuque (LA 1064)
Sample Size	4	4	6	4
Na_2O	2.14 0.19	1.88 0.34	1.69 0.38	1.52 0.34
MgO	1.81 0.19	1.55 0.29	1.58 0.36	1.86 0.26
Al_2O_3	14.03 0.96	15.49 0.58	14.28 1.19	14.80 0.34
SiO_2	69.03 0.99	67.78 0.92	68.45 3.84	65.07 0.78
P_2O_5	0.06 0.01	0.09 0.03	0.14 0.07	0.10 0.02
K_2O	3.79 0.72	4.06 0.52	3.94 0.26	3.50 0.37
CaO	2.02 0.53	2.32 0.90	3.16 1.61	4.60 2.44
TiO_2	0.26 0.07	0.42 0.11	0.43 0.13	0.57 0.04
MnO	0.03 0.01	0.06 0.01	0.06 0.01	0.08 0.03
Fe_2O_3	2.63 0.52	3.33 0.23	3.22 0.83	4.20 0.08
Sr	178 24	163 69	172 50	202 39

TABLE 4. Major oxide (%) and trace-element (ppm) composition of prehistoric and protohistoric pottery of the northern Rio Grande valley.

	Truchas[1] (LA 321)	TA-33[1]	Cochiti1 (LA 543)	Gallisteo[2] (LA 26)	Tonque[3] (LA 240)	She[4] (LA 239)
Sample Size	5	14	4	5	6	3
Na_2O	1.37 0.20	1.64 0.61	1.44 0.42	1.73 0.30	2.20 0.32	1.17 0.14
MgO	2.33 0.17	1.80 0.75	2.25 0.52	1.77 0.49	1.90 0.36	2.50 0.24
Al_2O_3	15.27 0.74	17.40 1.50	15.58 1.41	14.44 1.22	18.60 1.10	18.16 0.45
SiO_2	64.85 0.95	65.35 2.77	63.50 6.10	67.35 2.24	61.32 1.69	60.91 2.95
P_2O_5	0.19 0.07	0.23 0.14	0.22 0.07	0.14 0.05	0.24 0.04	0.26 0.05
K_2O	3.79 0.30	2.89 0.47	2.79 0.74	3.83 0.44	2.15 0.52	2.84 1.10
CaO	3.33 1.35	2.38 1.31	6.20 2.53	3.62 1.47	4.69 0.95	4.75 0.63
TiO_2	0.57 0.03	0.63 0.12	0.78 0.33	0.44 0.08	0.83 0.06	0.73 0.05
MnO	0.07 0.02	0.06 0.02	0.08 0.03	0.08 0.03	0.11 0.02	0.11 0.03
Fe_2O_3	4.60 0.38	4.89 0.97	5.11 1.97	3.89 0.69	5.07 0.79	6.03 1.11
Sr	236 62	252 155	320 117	207 97	748 98	622 134

[1]Pottery from these pueblos consisted of a mixture of many types and from many periods.
[2]Pottery consisted of a mixture of Bisquit (2), Tewa Polychrome (2), and Powhage Polychrome (1) wares.
[3]Pottery consisted of a mixture of Glaze A(1) and Glaze C(5) wares.
[4]Pottery consisted of a mixture of Glaze A(1) and Glaze C(2) wares.

from widely varying cultures, traditions, and periods of history, show a greater heterogeneity than the samples from the other pueblos, as expected.

By comparing the magnitude of the variances for each of the oxides or elements within each pueblo with that between the pueblos, those elements which show the greatest ability to discern one pueblo from another can be selected. An analysis of this sort shows Sr is the most useful and K is second, followed closely by Al and Si. The other major elements contribute to a much lesser degree, and the remaining trace elements provide almost no additional separation. Although clustering could be done with just Sr or any subset, it is generally wise to include as much of the data available as possible. This is especially true when the variables are highly correlated, as Sr, K, Al, and Si are in this case, since the increase in information as variables are added to the data matrix is not as great as expected. For the maximum discerning ability a more sophisticated treatment such as principal-component analysis should be employed.

Figure 3 is a cluster plot of the most useful diagnostic variables, Sr and K,O, for the Tewa Red and Polychrome wares of some pueblos and Spanish settlements (Glazed ware was used for Tongue). Clearly, with just these two variables many of the pueblos can be differentiated, though they cannot be sorted stylistically or by temper. SS 16/T can also readily be divided into two distinct groups, SS 1 and SS 2. Though Sr accomplishes most of the separation, K_2O was significantly lower (95% confidence, t test) in the Tewa Polychrome compared to the Tewa Red ware (3.85% versus 4.05%) for Cuyamungue, where eight samples of each were available and could be clearly identified. This is probably due to differences in the surface slips rather than any difference in the main body, and none of the other elements showed a difference. The variability between the Polychrome and Red ware of a given pueblo is also much less than that between pueblos, so for the cluster analyses these two stylistic types were combined.

The results of a pattern-recognition cluster analysis of selected pueblos are presented in Figure 4. Four major clusters are apparent in this diagram: the Espanola Basin, with Santa Clara, Sakona, Cuyamungue,

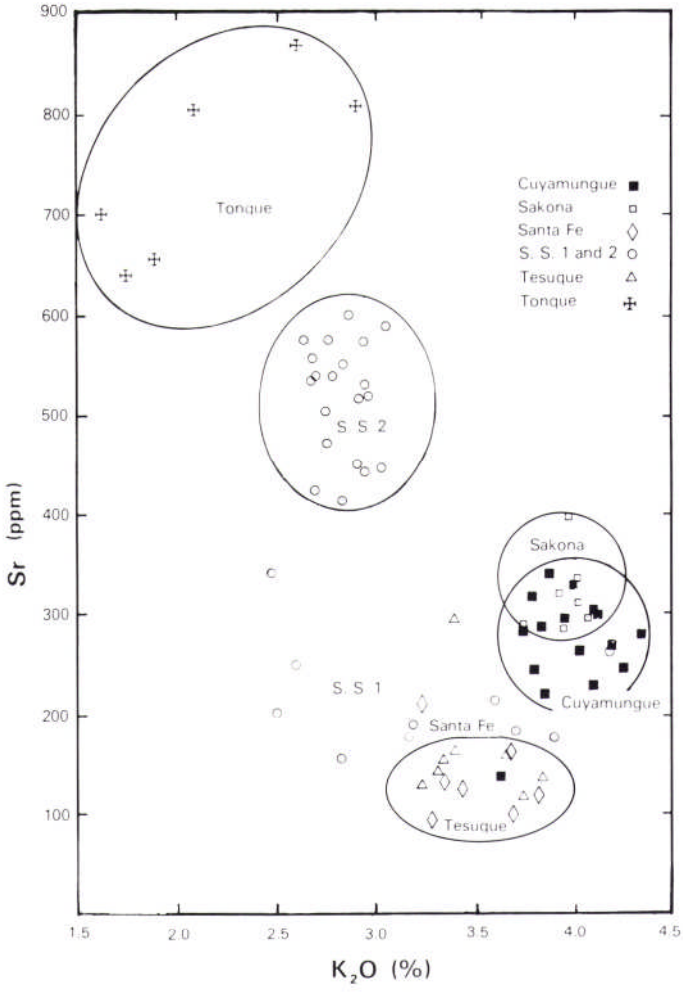

FIGURE 3. Cluster diagram using two variables for comparison of four pueblos and two Spanish settlements.

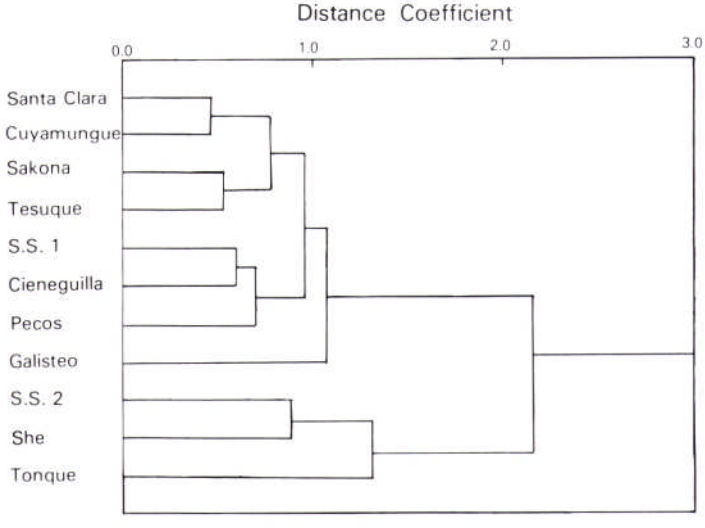

FIGURE 4. Cluster-analysis dendrogram using ten variables to compare eight pueblos and two Spanish settlements (SS 1 and 2, and Cieneguilla).

and Tesuque; the Santa Fe group, including part of the Spanish settlement's pottery, Cieneguilla (which was both a Spanish settlement and a pueblo), and Pecos; the Galisteo Basin north of the Galisteo River; and the region around the Ortiz Mountains south of the Galisteo River.

The samples of Glaze ware from She and Tongue which were analyzed contained hornblende that could be readily identified by XRD (Fig. 5). The hornblende was also found in two-thirds of the Spanish settlement samples. The differences in the Na_2O and AI,0, between SS 2, Tongue, and She could be due, in part, to the large differences between the slipped surface of the Tewa Red and Polychrome ware compared to the glazed surface of the Glazed ware, though actual decorations were avoided. It is also possible, however, that the SS 2 samples came from yet another source somewhere near the Ortiz Mountains.

It is worth noting that the XRD spectra (Fig. 5) are also useful for making distinctions between the pueblos of the Espanola Basin, clearly pointing out the differences in the varieties of mica and feldspars present. For example, illite has a broader spectral line at 8.8 degrees than muscovite and some of the more crystalline micas, and is present in the samples from Tesuque, but not from Sakona. On the other hand, the samples from Sakona show a broad background due to glassy tuff centered at 24 degrees, which is less apparent in the Tesuque samples and nearly absent in the samples from south of Santa Fe. The feldspars are in different ratios in the samples from below Santa Fe compared to those of the Espanola Basin. The Spanish settlement group 1 samples could not be differentiated from the Tesuque Pueblo samples by XRD alone. Because XRD does not provide quantitative data with the same degree of precision as XRF, it is less useful for parametric pattern-recognition techniques. However, XRD measures a different physical parameter than XRF, so it can discern differences not apparent with XRF.

By comparing the compositions of the Spanish settlement group 2 pottery with those from She, it is possible to conclude that a common clay or temper source may have been used for their manufacture. The higher concentration of Sr in the She pottery is caused by a single Glaze A piece, pointing out the major problem with an analysis such as this. The sherd may not be of local manufacture, as its Sr content matches those from Tongue. There is little guarantee that all the pottery samples from a given pueblo were locally made. However, with an appropriate cluster analysis the number of distinct sources can be identified, and then the only problem is to match them with the correct pueblos.

If the SS 2 samples came from near She, the presence of a source of "Tewa" pottery around She strengthens the idea that the Tano were related to the northern Tewa. Possibly the SS 2 sherds actually predate the SS 1 sherds, coming from trade which took place prior to the revolt of 1680-1696. After the revolt many of the Tano left the Galisteo Valley, moving first to the Santa Cruz River and then in 1706 to Hano Pueblo located among the Hopi of northeastern Arizona. Possibly trade between the Spanish settlement and the Tano ended at that time and the Spanish obtained their pottery from a more local source, as the pottery labeled SS I is very similar to the Santa Fe and Pecos pottery. If this is so, the southern Tewa were involved in the production of "Tewa" ware from its inception.

CONCLUSIONS

XRF and XRD demonstrate that differences can be detected between the various pueblos as production centers even during a period when exchange of ideas made stylistic differences difficult to discern. In addition, the parametric nature of the data obtained from XRF readily lends itself to cluster analysis, helping to make clear the pattern of exchange taking place between the early Spanish settlements and the pueblos. An unidentified center of production, probably located south of Galisteo, was important during the early historic period, presumably being responsible for two-thirds of the red wares unearthed at site 16/T. A search for this site should provide an interesting piece of archaeological detective work, and, if found, could give important new information about trade in the area.

The archaeometric study demontrated that a single element (Sr) may be used as a diagnostic tool for locating this site, though a more complete

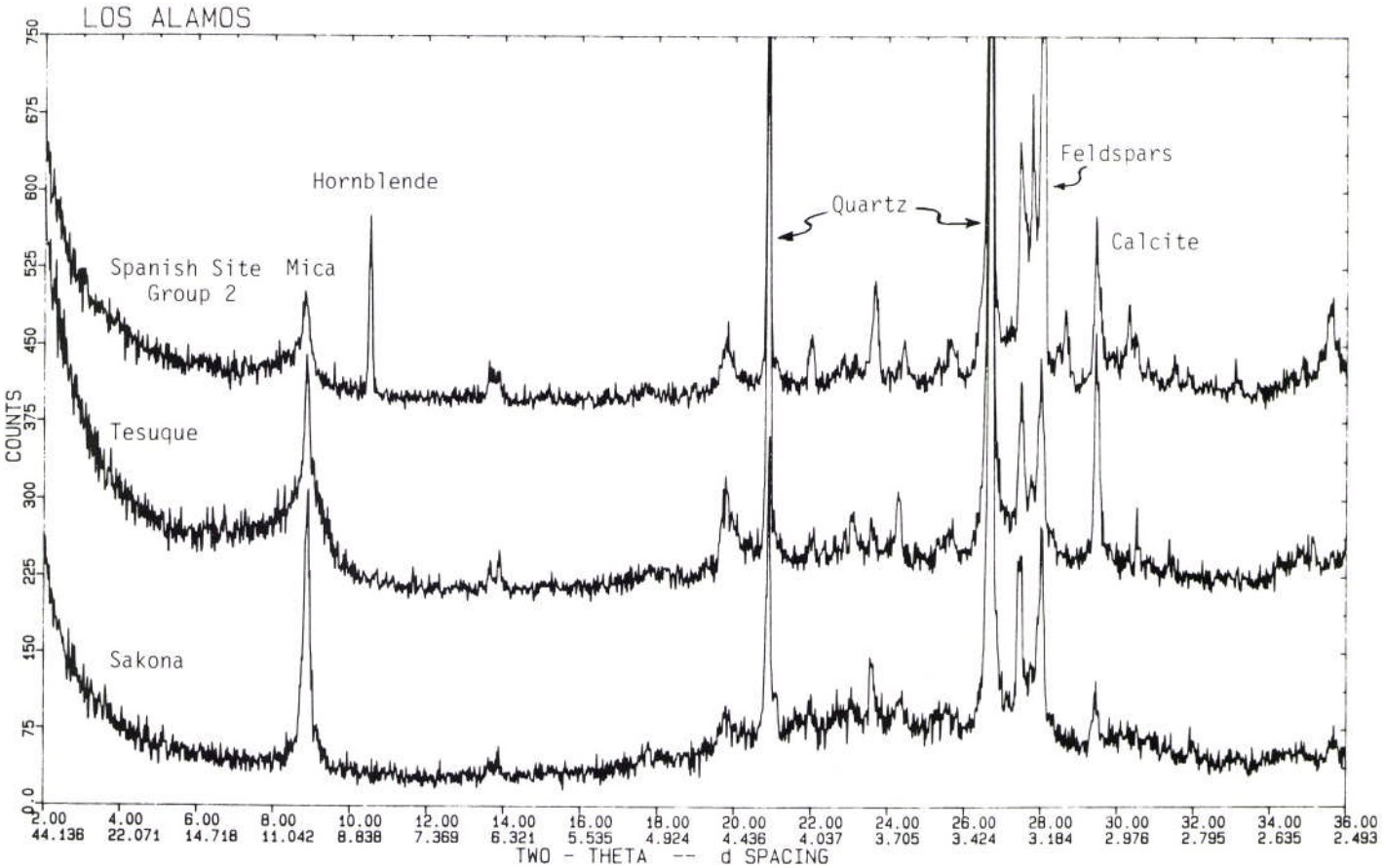

FIGURE 5. XRD spectra of three typical sherds from two pueblos and SS 16/T.

analysis used in conjunction with a petrographic study or XRD analysis for hornblende would be more conclusive. The study also demonstrated that the number of sherds analyzed from a given site need not be large if enough parameters (elements in this case) are measured and if the number of imported sherds at that site is not great. It is important to use as few samples as possible not only as a saving in labor, but also because the analysis is destructive of valuable artifacts. By using cluster analysis on parametric data, even imported pottery can be identified as such and the number and locations of centers of production can be estimated.

ACKNOWLEDGMENTS

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The southbound "mixed train daily" stops at Embudo in July 1941. The stone veneer depot was the work of station agent Henry Wallace (photo by Bob Richardson).